Level Measurement

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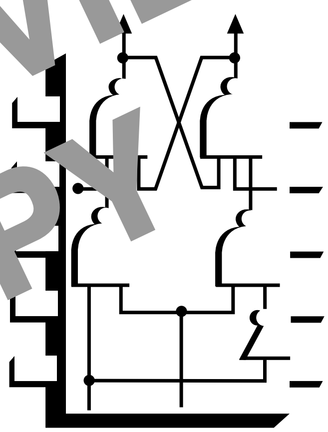
LEVEL MEASUREMENT

Lesson One

Principles of Level Measurement



TPC Training Systems

27601

Lesson

1 Principles of Level Measurement

TOPICS

Measuring Liquid Level
Surface-Sensing Gauges
Storage-Tank Gauges
Sight Glasses
Magnetic Gauges
Buoyancy
Displacer Gauges
Level Switches
Mercury Level Switches
Level Switches with Multiple Displacers
Magnetic Reed Switches

OBJECTIVES

After studying this Lesson, you should be able to…

- Define datum point, and contrast direct and indirect level measurement.
- Describe the main kinds of surface-sensing gauges.
- Define buoyant force and explain how it is used in displacer gauges to measure liquid level.
- Describe maintenance procedures for float devices, displacer gauges, and sight glasses.
- Compare the use of sight glasses, mercury level switches, and magnetic reed switches.

KEY TECHNICAL TERMS

Datum point 1.03 a fixed reference point from which level is measured

Head 1.13 pressure caused by a column of liquid

Buoyancy 1.22 upward force exerted by a liquid on an object submerged or floating in it

Buoyant force 1.23, 1.24 net upward force exerted by liquid on a submerged or floating object; equal to the weight of the displaced liquid

Displacer 1.27 a nearly stationary object whose purpose is to displace liquid, used for liquid level measurement

Level measurement is one of the oldest and most common of all measurements. People have been measuring the level of water in lakes and the level of grain in storage bins for thousands of years. A century ago, boat hands on the Mississippi River measured the level of the river by tossing out a weighted rope that had knots tied at 1-ft intervals. When the weight touched bottom, the number of knots from the weight to the surface showed whether the water was deep enough for safe passage. As late as the early 1900s, the most common level-measuring tool was a stick. A notch carved every few inches made reading the level easy.

This Lesson discusses the basic principles of level measurement. It also describes some simple instruments for measuring, indicating, and controlling liquid level.

Measuring Liquid Level

1.01 In general, process variables can be measured either *directly* or *indirectly*. Both methods are used to measure liquid level. For example, it is easy to make a direct measurement of water level, as shown in Fig. 1-1, by lowering a measuring stick into the water and reading the water level directly on the stick. You can even mount a stick permanently in a tank, then read the level without handling the stick.

1.02 However, suppose the tank contains sulfuric acid instead of water. And suppose the acid is hot and under high pressure. Then you will probably need to measure the level indirectly.

1.03 Liquid measurements need two reference points—the *surface* of the liquid being measured and the *datum point*, which may be the bottom of a tank, the top of a tank, or any other point that remains stationary. All liquid level measurements are made from the datum point (the fixed reference point) to the surface of the liquid being measured.

1.04 Some level-measuring instruments—for example, one-point switches—operate only when the level reaches them. They can be used to operate valves, pumps, or alarms. Other instruments provide a continuous level measurement and require more complicated control systems.

Surface-Sensing Gauges

1.05 One way of measuring the level of the liquid in an open tank is to use a point gauge. A *point gauge* is a metal rod with a pointed end. To use it, you lower the rod until the point just touches the surface of the liquid. A scale on the rod allows you to read the distance from the surface to the datum point.

1.06 Figure 1-2 on the following page shows a level-measuring device similar to a point gauge. It is a flexible metal tape with a plumb-bob on the end. To use it, you unwind the tape until the plumb-bob touches the surface of the liquid. The tape measures the distance from the datum point to the surface. Note that this can be a *continuous* measurement over a range determined by the tape length if the plumb-bob is replaced by a float and a reeling device is provided.

Storage Tank Gauges

1.07 In many cases, measurements can be made automatically. Figure 1-3 on the following page shows an automatic system used to measure the level of water in a storage tank.

Fig. 1-1. Measuring liquid level directly

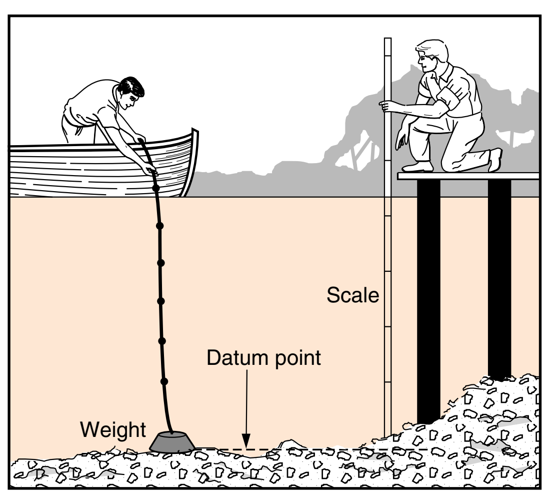
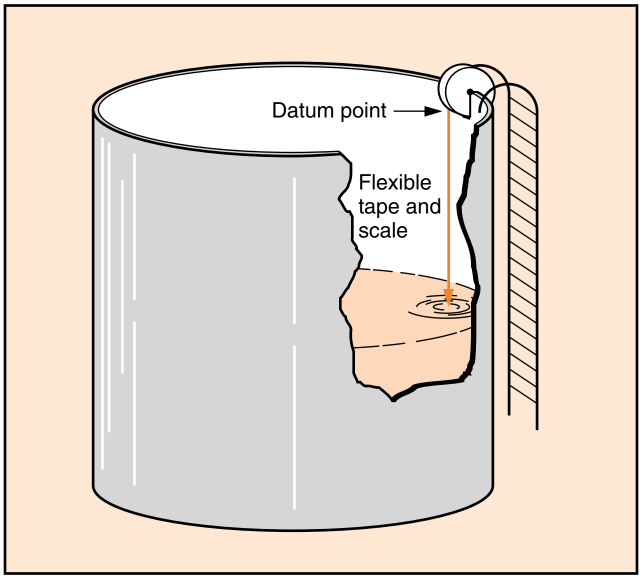


Fig. 1-2. Flexible tape and plumb-bob



1.08 The system in Fig. 1-3, called a *storage-tank gauge*, has a float that rises and falls with the surface of the liquid. A perforated tape connected to the float passes through the tank top and into the gauge head. A spring motor keeps the tape taut and exerts a constant tension at the float. A sprocket wheel drives a shaft, which in turn drives a counter mechanism. The counter can be calibrated to show the *volume* of water in the tank instead of the depth. The size and shape of the tank determine how many gallons (or liters, or cubic feet) of water are in the tank for every unit of depth.

1.09 The most common maintenance problems with float-actuated level gauges often occur where the process liquid contacts the float. The guide cables sometimes break or become corroded, and the tape attached to the float can break or become twisted. Also, corrosion can cause holes in the float.

1.10 The gauge head may be filled with oil to lubricate and protect the internal parts from corrosion. The gauge has a drain plug that should be removed before servicing. You can maintain the counter by applying a lightweight lubricating oil to moving parts:

- You should use an uncompounded low-pour mineral oil where the ambient temperature is lower than 32°F (0°C).
- For temperatures down to -20°F (-29°C), you should use a transformer oil.
- For temperatures below -20°F, you should use a low-viscosity synthetic-base oil.

1.11 To repair a float level device, you may have to enter the vessel in which it is installed. *Never* enter *any* vessel without someone standing by outside. Sometimes you can unbolt the flange between the gauge and the tank and pull the float out. Either way, you must be sure to have all the needed permits. You must also wear appropriate safety clothing. Work on tanks containing caustic,

Fig. 1-3. Storage-tank gauge

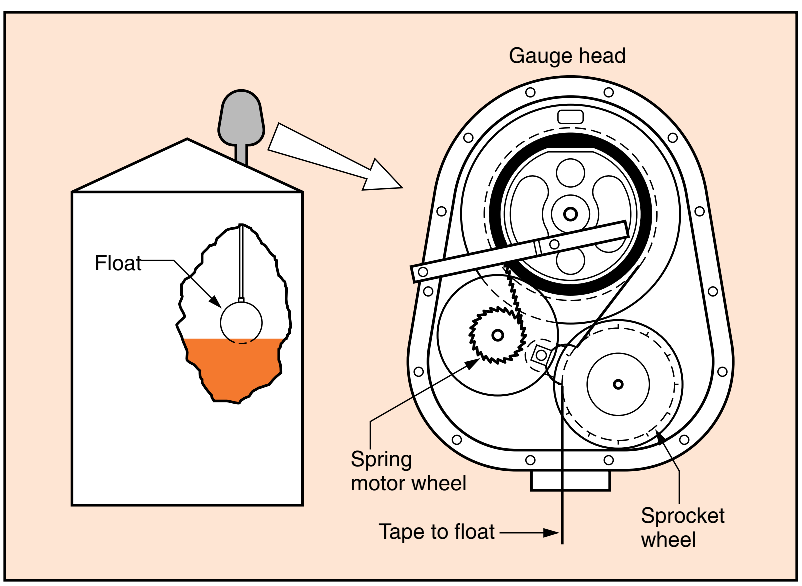
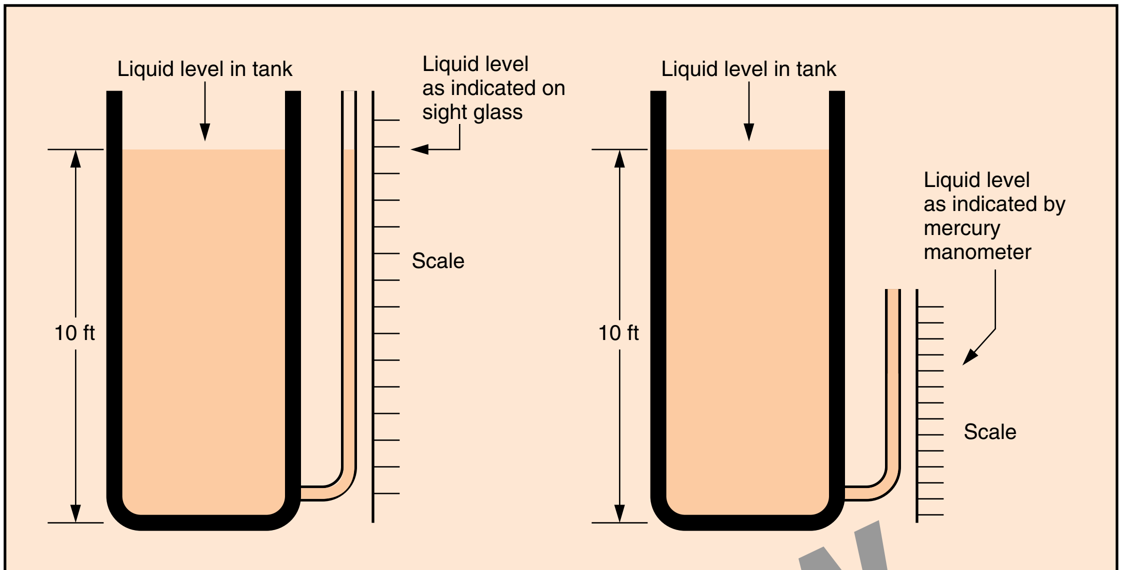


Fig. 1-4. Sight glass and mercury manometer



corrosive, or acidic liquids requires goggles, gloves, apron, and perhaps a gas mask. Even if the process fluid is harmless, you should wear safety glasses, as you should during any instrument work.

Application 1-1

Some oil tankers use float level gauges to determine liquid levels in their tanks. Because a ship lists from side to side, the level in the tanks would appear to change if the gauges were not calibrated to display tank volume. One way to obtain accurate volumes is to install the float gauges at the tank centerline and make all measurements there. The float can be guided by cables attached to the bottom of the tank. Once the correct tank volume is obtained, corrections due to apparent volume shrinkage or expansion can be calculated.

Sight Glasses

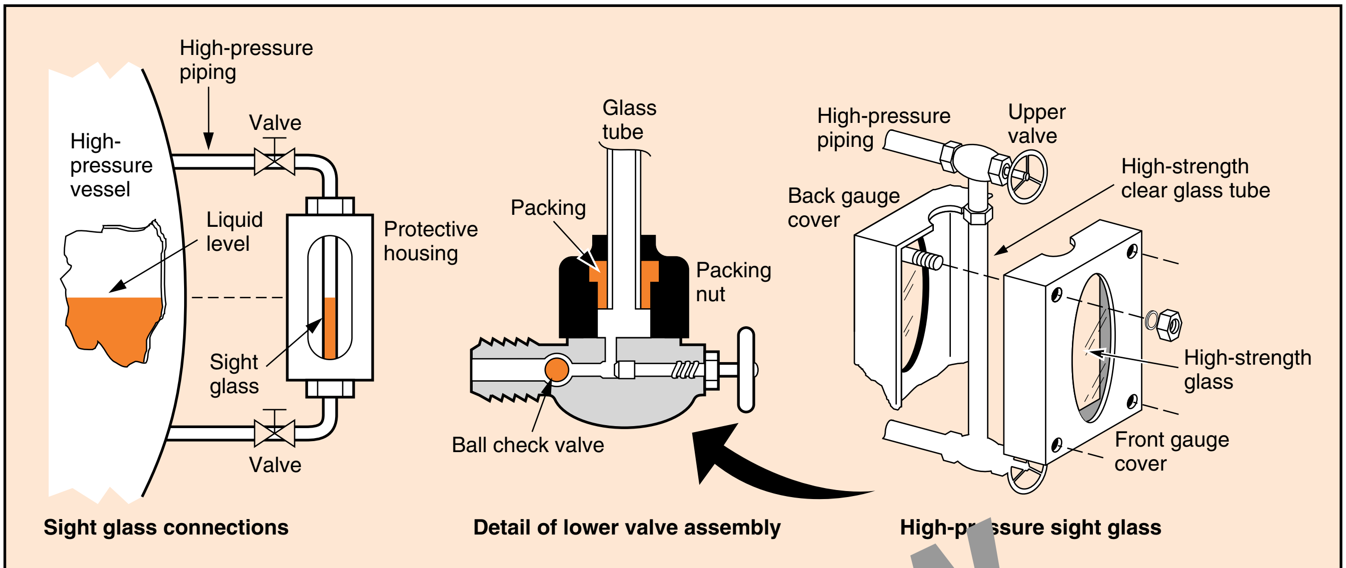
1.12 The construction of some tanks makes it impossible to touch the surface with a rod or float. A sight glass, shown on the left in Fig. 1-4, can be used to measure levels in these vessels. The liquid level in the sight glass matches the level of liquid in the tank. As the level in the tank rises and falls, so does the level in the sight glass. In some cases—for example, a very high tank—it may not be convenient to use a sight glass to measure level, although a TV camera sometimes can monitor out-of-reach sight glasses.

1.13 If you use a heavy liquid (often mercury) in a sight glass, the scale can be reduced by the ratio of the relative density of mercury to that of the tank liquid. This is actually a measurement of the pressure caused by the level (*head*), a principle often used for automatic control. Fewer inches of mercury are needed to register the same pressure as would be indicated by a high column of a less dense liquid. You can use a much shorter sight glass, as shown on the right in Fig. 1-4, and need not climb a ladder to read the level.

1.14 When using a mercury manometer, be sure that it is installed so that excessive pressure cannot blow the mercury out of the top of the manometer. Mercury is dangerous and expensive, and federal safety laws are making it increasingly unpopular. Remember that you can use almost any liquid in a manometer, as long as you know the liquid's relative density and calibrate the manometer accordingly.

1.15 If the tank is under pressure or vacuum, the sight glass or manometer must be connected to the

Fig. 1-5. High-pressure sight glass



tank at the top as well as at the bottom. Otherwise the pressure difference between the tank and the sight glass would cause a false reading.

1.16 With appropriate safety precautions, sight glasses can be used in high-pressure tanks, as shown in Fig. 1-5. The glass tube must have a small inside diameter and a thick wall and must be enclosed in a protective housing. A check valve in each connecting line isolates the gauge from the tank by snapping shut if the sight glass breaks.

Magnetic Gauges

1.17 Magnetic gauges can often be used in applications where a sight glass is not practical. A *magnetic gauge* uses the attraction between two magnets to follow the level of a liquid. One magnet floats on the surface of the liquid. The other magnet is inside a nonmagnetic tube passing through the liquid.

1.18 Figure 1-6 shows a magnetic gauge. The tube passing through the liquid is made of a nonmagnetic metal. The magnet inside the tube is balanced by a counterweight so that it can rise or fall easily. The ring-shaped floating magnet fits around the outside of the tube and follows any change in the liquid level. The magnet inside the tube follows the floating magnet and moves the indicator along a calibrated scale.

Application 1-2

A pharmaceutical manufacturer uses sight glasses with proximity switches to control the level in the oxygenation vessels. The process involves forcing compressed oxygen into an enclosed tank of water, thus forming the microbubbles of oxygen necessary for the next step in the process.

The sight glass lets an operator see at a glance that the microbubbles are indeed being produced. The observer can also estimate the approximate size and concentration of bubbles and decide if a laboratory test is needed. Before the installation of the sight glasses, microbubble production was monitored only by lab tests. By eliminating constant testing, the company saved time and money.

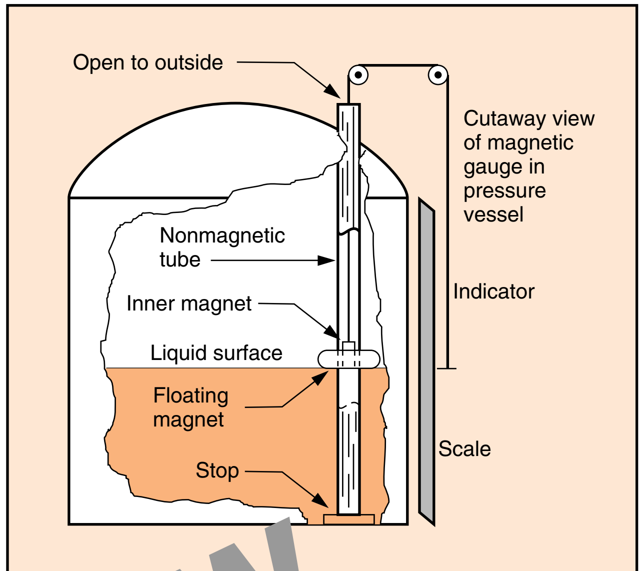
Another significant improvement came from mounting proximity switches on the sight glasses instead of using displacer switches. These proximity switches are sensitive enough to detect the presence of water through the clear sight glasses. The switch is simply clamped onto the glass, so the operator can easily move the switch to adjust the level at

which the pump starts or stops. If the switch needs repair, it can be replaced with a new switch and repaired elsewhere. The previous displacer switches could not be repaired without stopping the process.

1.19 Notice in Fig. 1-6 that the tank is completely sealed. The liquid does not leave the tank as it would if you used a sight glass. There is nothing outside the tank that can break, leak, or become jammed.

1.20 However, magnetic gauges should not be used to measure liquids that can cause the floating magnet to stick to the tube. Also, the material for the tube itself must be able to withstand the temperature, pressure, and chemical action of the liquid that is being measured.

Fig. 1-6. Magnetic gauge



Buoyancy

1.21 All the level-measuring devices described so far indicate level by sensing the surface of the liquid or its pressure (head). However, another method of measuring level does not sense the surface directly. Instead, this method uses the buoyancy of a partly submerged object to determine liquid level. As the level changes, the force of buoyancy changes, which moves an indicator calibrated to show the level of the liquid.

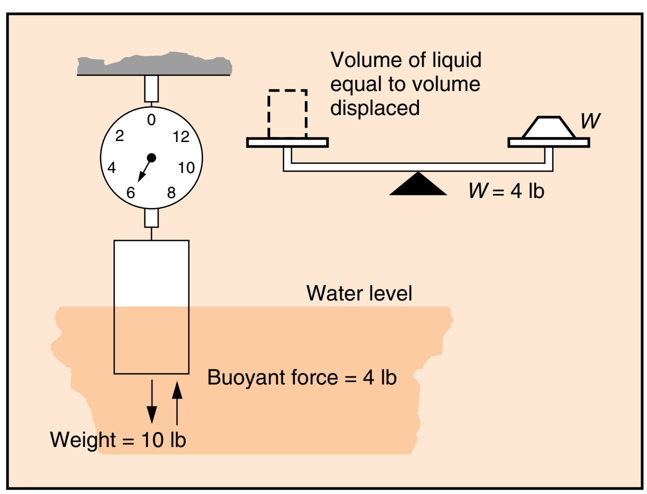
1.22 *Buoyancy* is the upward force exerted by a liquid on an object submerged or floating in it. For example, if you wade from shallow water into deep water, you can feel the effect of buoyancy on your body. As the level of the water rises around you, the water supports your body with increasing upward force, and your feet support less and less of your weight. When the water becomes shoulder deep, your feet support almost none of your weight. Walking then becomes difficult, partly because you cannot get a solid footing on the bottom.

1.23 Figure 1-7 shows the effect of buoyancy on a metal cylinder. Suppose the cylinder hangs on a spring scale over (but not touching) a tank of water. Out of the water, the cylinder weighs 10 lb. When the water level rises, part of the cylinder is submerged in the water. The water then exerts pressure on the submerged part of the cylinder, producing an upward force on the cylinder. This force is referred to as *buoyant force*.

1.24 The buoyant force equals the weight of the water displaced by the cylinder. The cylinder in Fig. 1-7 displaces 4lb of water. Therefore, the buoyant force is 4lb. The scale shows that the cylinder appears to weigh only 6lb—10lb actual weight minus 4lb buoyant force equals 6lb apparent weight.

1.25 The buoyant force on an object depends on how much liquid is displaced and the density of the

Fig. 1-7. Buoyant force on cylinder



liquid. The buoyant force always equals the weight of the displaced liquid. If the buoyant force becomes equal to the object's weight, the object floats.

1.26 The buoyant force reaches its maximum when the object becomes totally submerged. Further increases in liquid level do not increase the buoyant force, because the object does not displace any more liquid.

The Programmed Exercises on the next page will tell you how well you understand the material you have just read. Before starting the exercises, remove the REVEAL KEY from the back of your Book. Read the instructions printed on the Reveal Key. Follow these instructions as you work through the Programmed Exercises.

1-1. Using a measuring stick in a tank of liquid is an example of __________ level measurement.	1-1. DIRECT Ref: 1.01
1-2. All liquid level measurements are made from the __________ to the liquid's surface.	1-2. DATUM POINT Ref: 1.03
1-3. Level measurement devices can be recalibrated to indicate __________ instead of level.	1-3. VOLUME Ref: 1.08
1-4. A storage tank gauge may be filled with __________ to protect the internal parts.	1-4. OIL Ref: 1.10
1-5. The liquid level in a sight glass is the same as the level in the __________.	1-5. TANK Ref: 1.12
1-6. The attraction between two __________ can be used to determine liquid level.	1-6. MAGNETS Ref: 1.17
1-7. The upward force exerted by a liquid on a submerged object is referred to as __________.	1-7. BUOYANCY Ref: 1.22
1-8. The buoyant force on an object depends on the amount of liquid displaced and on the _________ of the liquid.	1-8. DENSITY Ref: 1.25

Displacer Gauges

1.27 One kind of level gauge uses buoyant force to measure liquid level on a nearly stationary object called a *displacer*. It is called a displacer because its purpose is to displace liquid. A force-measuring mechanism senses changes in the buoyant force and converts this force into an indication of level. Displacers provide a continuous measurement over a range determined by their length and can be made into transmitters for automatic level control in shallow vessels.

1.28 Figure 1-8 shows a displacer mechanism for measuring liquid level. The displacer moves up and down only a little way, perhaps only a fraction of an inch. As the liquid level changes, the buoyant force moves the displacer slightly and twists the torque tube. The motion of the torque tube moves the pointer to indicate the liquid level on the scale.

1.29 The pointer's total rotation is only 2 to 7°. The amount of pointer rotation depends on the following conditions:

- the size, shape, and weight of the displacer
- the length of the support arm
- the stiffness of the torque tube
- the density of the liquid
- the range of variation in the liquid level.

1.30 Suppose you want to use a displacer gauge to measure the level of water (recall that the relative density of water is 1.0). Assume the full range of the gauge is 18 in. at a relative density of 1.0. As the liquid rises, the displacer becomes lighter by the weight of liquid displaced.

1.31 The change of weight causes the torque tube, which had been at point X (no water coverage), to begin to twist upward. As the liquid continues to rise, the displacer eventually becomes completely submerged and the torque tube rests at point Y (maximum water coverage).

1.32 Now suppose you want to use this gauge to monitor the level of kerosine in a tank. The relative density of kerosine is 0.8. You know that the displacer will displace the same volume of kerosine as water. However, for a certain volume, kerosine weighs less. The relative density tells you that kerosine weighs 20% less than water.

1.33 As the level of kerosine rises, you can see that a total rise of 18 in. no longer causes the pointer to cover the full range—that is, to move from X to Y. For kerosine the total rise is 22.5 in.:

Fig. 1-8. Typical displacer gauge

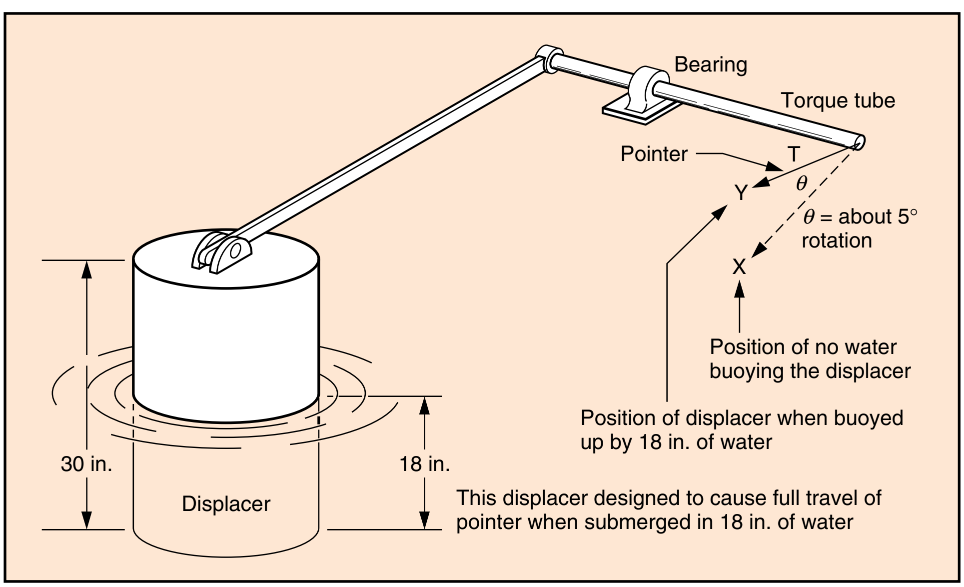


Fig. 1-9. Magnetically coupled displacer

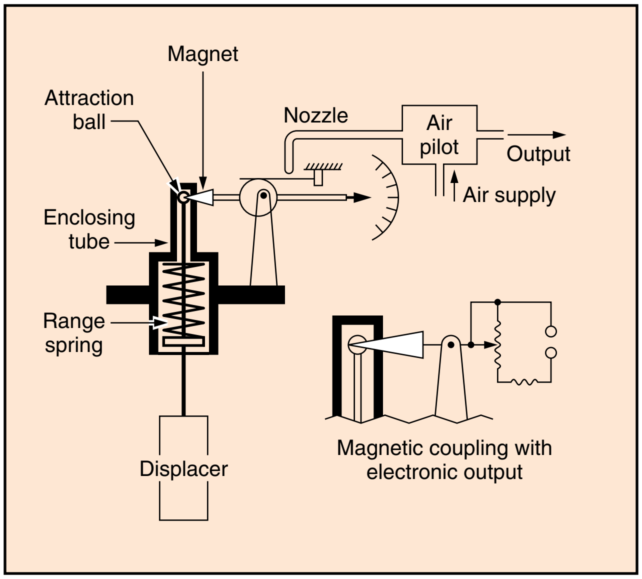
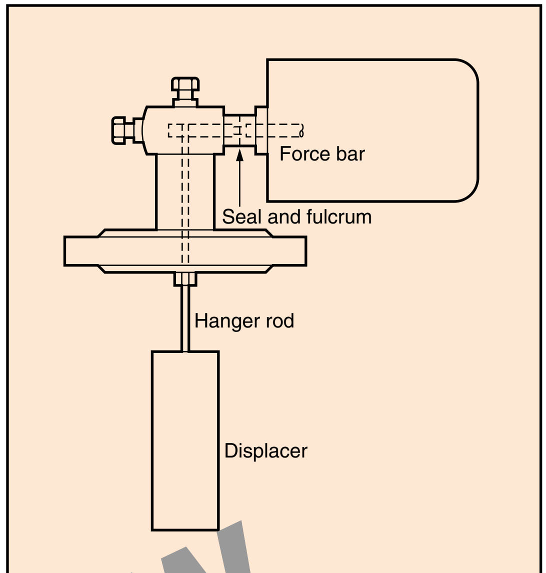


Fig. 1-10. Displacer with force-bar transmitter



$$\frac{18 \text{ in.}}{0.8} = 22.5 \text{ in.}$$

That is, the total rise in the level of kerosine that is needed to rotate the torque tube from point X to point Y is 22.5 in., not 18 in. as for water.

1.34 The range of the gauge changes because the density of kerosine is lower than the density of water. A greater volume of displaced kerosine is needed to produce the same buoyant force as water. In other words, displacing a volume of kerosine produces less buoyant force than displacing an equal volume of water.

1.35 One way you can modify a displacer gauge for use with a different liquid is by replacing the displacer with one of a different diameter. If the new liquid is less dense than the former liquid, the new displacer should have a greater diameter than the previous one. The larger displacer will displace a greater volume of liquid for the same change in level. However, because of the different densities, the greater volume will weigh the same amount as the smaller volume of denser liquid. If the new liquid is more dense than the former liquid, the new displacer should have a smaller diameter.

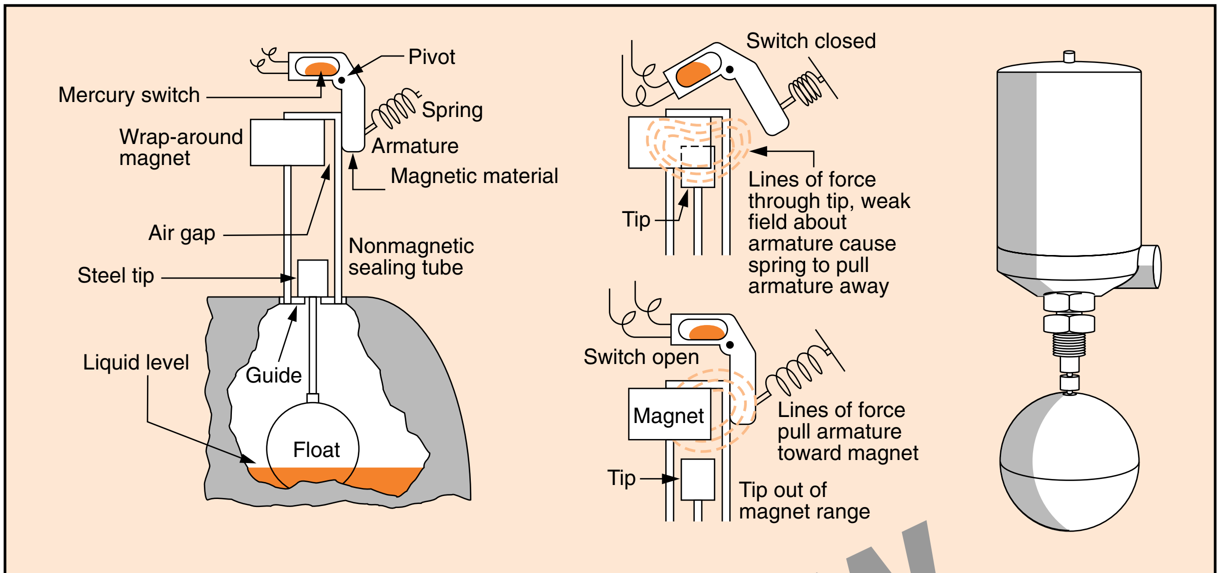
1.36 Many kinds of displacer-actuated devices are used in industry. Figure 1-9 shows a spring-balanced, magnetically coupled displacer. In this device, the range spring replaces a torque tube. The spring rises and falls along with the displacer, converting the level measurement to a pneumatic or electronic signal. Magnetic coupling isolates the instrument's electronics from the process liquid.

1.37 Figure 1-10 shows a displacer with a force-bar transmitter. The force-balance diaphragm serves both as a fulcrum for the force bar and as a seal to the process. The force-bar transmitter can convert the changes in the displacer's weight to an electronic signal or to a standard pneumatic (air) signal.

1.38 The primary maintenance you will probably have to perform on a displacer-actuated level-measuring device is removing the torque tube, inspecting it, and repairing or replacing it. You must be very careful when you are replacing a displacer or torque tube. The displacer must be supported by a rope or chain as you disconnect it from the rod. If the displacer is dropped, its weight might damage the displacer well.

1.39 You should choose the weight of a displacer to match the density of the liquid, and its length should be appropriate for the measuring range. A proper match means that the instrument dial will move over its full range as the level changes from minimum to maximum.

Fig. 1-11. Level-control switch for low-pressure tank



Level Switches

1.40 Many of the process control instruments used in industry today are not designed to provide the operator with a reading of the process variable. Instead, the instruments are designed to throw a switch, adjust a valve, or perform some other action to keep the process running smoothly.

1.41 Similarly, level-measuring instruments do not always provide a reading of the level. Frequently, all that the level instrument does is respond correctly when the level reaches an upper or lower limit. At the upper limit, the instrument acts to reduce the level. At the lower limit, it acts to raise the level. For example, a level instrument may be set up to open or close an electrical switch. The switch in turn may operate an alarm, start or stop a pump, or open or close a valve.

1.42 A tank usually has both a high- and a low-level switch. Imagine a tank with just one switch. The level rises and operates the switch. A valve opens to drain the tank and, as the level falls, the switch changes state. The valve closes, the level rises, and the switch operates again.

1.43 To prolong the life of the valve or pump and to prevent cycling, two level switches must be installed. When the high-level switch operates, the valve opens. It does not close until the level falls below the low-level switch. Then the level rises until it reaches the high-level switch again. The distance between the switch settings is referred to as *deadband*. Level within the deadband is unknown unless otherwise indicated.

1.44 Opening or closing a switch sounds like a simple task, but may require quite a complex mechanism. Simple actions often become complex when you try to increase their reliability, especially under harsh or dangerous operating conditions.

Mercury Level Switches

1.45 Figure 1-11 shows an example of a simple switch used for controlling level in a low-pressure tank. The switch is a mercury switch that controls the level by turning a pump on and off. When the mercury makes contact with the two terminals, the switch is closed. When the mercury rolls away from the contacts, the switch is open.

1.46 Normally a magnet holds the pivoted armature in a position where the switch is open and the pump is turned off. As the liquid level rises in the vessel, the float lifts the steel tip until the tip comes near the magnet. The steel tip interferes with the magnetic field and weakens the magnet's pull on the armature. The armature then pivots, causing the switch to close and turn on the pump. The pump lowers the level in the tank. When the steel tip drops away from the magnet, the armature swings back to its original position and the switch opens, thus turning off the pump.

1.47 The sealing tube shown in Fig. 1-11 cannot be used in very high-pressure applications. For such special applications, the float mechanism and the switch often are enclosed in a separate unit, as shown in Fig. 1-12. The float is enclosed in a float chamber, and the float chamber is connected to the tank by pipes. Valves in the pipes allow you to isolate the level instrument from the tank.

Level Switches With Multiple Displacers

1.48 The liquid in some tanks is turbulent enough to make a float bounce, causing the level switch to turn on and off randomly. You can solve this problem by placing a stilling well around the displacer, or you can use a switch that has several displacers, as shown in Fig. 1-13.

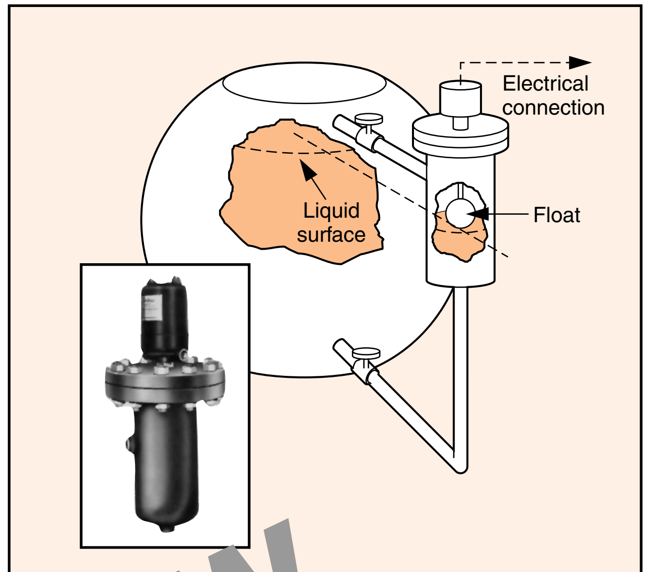
1.49 In a multiple-displacer switch, displacers are more dense than the liquid, and some of the displacers are submerged at all times. A spring on the line helps support part of the weight of the displacers. The buoyant force of the liquid supports the rest of the weight.

1.50 Rapid changes in level have no effect on the submerged displacers—and very little effect on the displacers at the surface. Yet the switch responds to significant changes in level. A disadvantage of this switch is that the displacers must be pulled out of the tank in order to change the point at which switching occurs.

Magnetic Reed Switches

1.51 Special types of switches are used if the liquid to be measured is a hazardous chemical or if it is at high temperature or high pressure. Figure 1-14 on the following page shows a method of switching in such cases. Each reed switch is normally open. When the floating magnet outside the tube comes near the switch, it attracts the magnetic pole piece in the switch. This action closes the switch until the floating magnet moves away. No follower magnet is needed inside the tube.

Fig. 1-12. Float mechanism for high-pressure tank



1.52 Note that Fig. 1-14 shows how a magnetic reed switch operates at three different levels inside the tube. Depending on their location, the switches act as follows:

- The bottom reed switch turns off the pump when the level of the liquid reaches its lower limit.

Fig. 1-13. Multiple-displacer switch

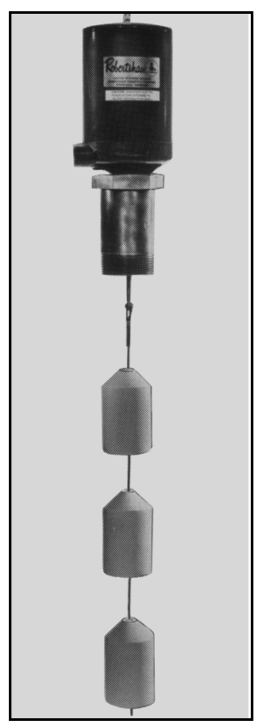
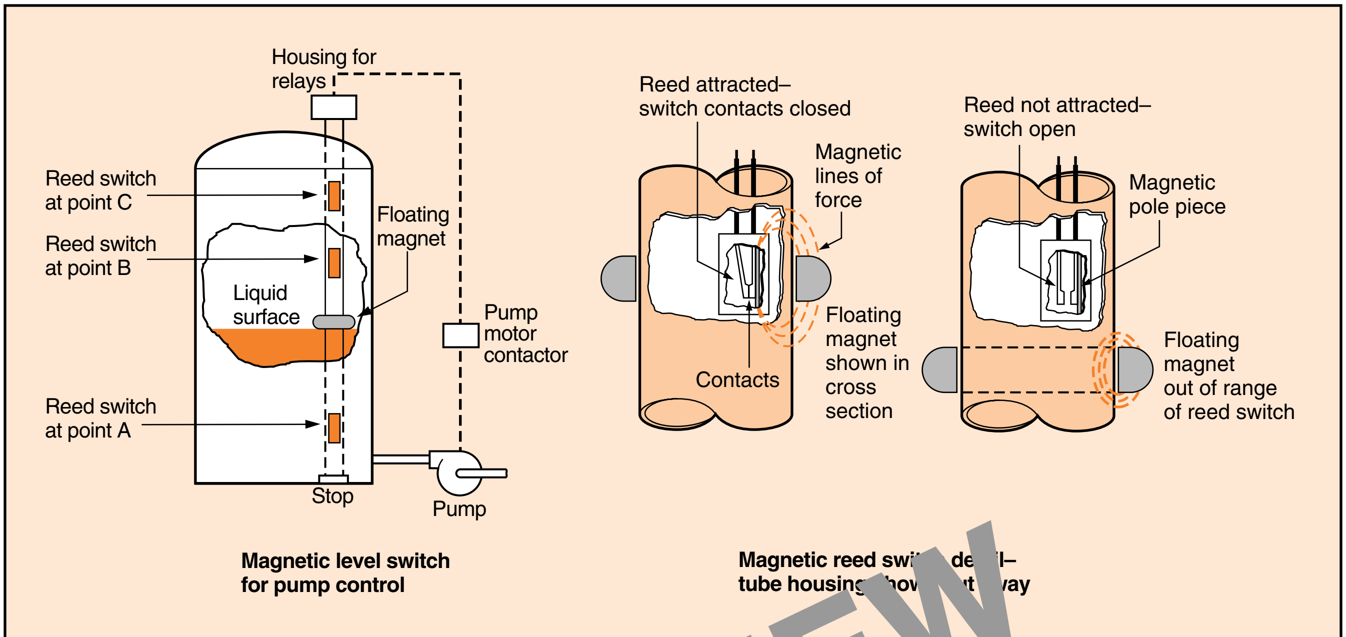


Fig. 1-14. Magnetic reed switch



- The middle reed switch turns the pump on when the level of the liquid reaches its upper limit.
- The highest reed switch sounds an alarm if the liquid reaches a dangerous level.

1.53 Magnetic reed switches can be serviced from the top of the tube. These switches are not sealed in the tube, and they never come into contact with the liquid in the tank.

1-9. In a displacer gauge, a change in the effective weight of a displacer causes the attached __________ to twist and move a scale pointer.	1-9. TORQUE TUBE Ref: 1.28, 1.31
1-10. Because kerosine's density is lower than that of water, it takes a(n) __________ volume of displaced kerosine to produce the same buoyant force as water.	1-10. GREATER Ref: 1.34
1-11. In a spring-balanced magnetically coupled displacer gauge, the torque tube is replaced by a(n) __________.	1-11. RANGE SPRING Ref: 1.36
1-12. The density of the measured liquid should determine the __________ of the displacer.	1-12. WEIGHT Ref: 1.39
1-13. Using two or more level switches on a tank will prevent __________.	1-13. CYCLING Ref: 1.43
1-14. When the mercury in a mercury level switch rolls away from the contacts, the switch is __________.	1-14. OPEN Ref: 1.45
1-15. When tank turbulence is great enough to bounce a displacer, you can use a(n) __________ or __________ to lessen the effect of the turbulence.	1-15. STILLING WELL, MULTIPLE DISPLACERS Ref: 1.48
1-16. If the liquid to be measured is a hazardous chemical, magnetic ________ switches can control liquid level without contacting the liquid.	1-16. REED Ref: 1.51, 1.53

Answer the following questions by marking an "X" in the box next to the best answer.

1-1. In liquid measurement, the datum point is always

- ☐ a. a fixed reference point
- ☐ b. a moving point on the liquid's surface
- ☐ c. at the bottom of a tank
- ☐ d. at the top of a tank

1-2. A storage-tank gauge is actuated by a

- ☐ a. displacer
- ☐ b. float
- ☐ c. magnet
- ☐ d. torque tube

1-3. When performing any instrument work, you should wear

- ☐ a. a gas mask
- ☐ b. gloves
- ☐ c. safety glasses
- ☐ d. safety shoes

1-4. If tank construction does not permit contact with the liquid's surface, you can detect level with a

- ☐ a. plumb-bob and tape
- ☐ b. point gauge
- ☐ c. sight glass
- ☐ d. storage-tank gauge

1-5. Buoyant force equals the

- ☐ a. gross pressure on the surface of the displacer
- ☐ b. liquid pressure minus atmospheric pressure
- ☐ c. weight of liquid displaced
- ☐ d. weight of the displacer

1-6. The torque tube in a displacer level gauge moves a pointer

- ☐ a. 2 to 7°
- ☐ b. 10 to 20°
- ☐ c. 12 to 17°
- ☐ d. 15 to 25°

1-7. The major maintenance task on a displacer gauge is inspecting and repairing the

- ☐ a. diaphragm
- ☐ b. displacer
- ☐ c. range spring
- ☐ d. torque tube

1-8. The float mechanism and switch in a mercury level switch must be enclosed in a separate unit for use with

- ☐ a. conductive liquids
- ☐ b. high-pressure tanks
- ☐ c. low-pressure tanks
- ☐ d. nonconductive liquids

1-9. A level switch with multiple displacers is used with

- ☐ a. corrosive liquids
- ☐ b. stilling wells
- ☐ c. tank stabilizers
- ☐ d. turbulent liquids

1-10. Which kind of switch is best suited for applications with hazardous chemicals or high pressures or temperatures?

- ☐ a. Magnetic reed switch
- ☐ b. Mercury level switch
- ☐ c. Multiple-displacer level switch
- ☐ d. Single-displacer level switch

SUMMARY

Liquid levels have been monitored for thousands of years, and some of the older measurement techniques are still in use today. For example, you can measure the level of a liquid in an open tank by allowing a float to contact the liquid's surface directly. A sight glass can be used to show level if you cannot contact the surface directly. If a sight glass is not practical, you can use a magnetic gauge, in which the attraction between two magnets is used to follow the level of a liquid.

Other devices depend on buoyancy. If the buoyant force becomes equal to the object's weight, the object floats. The displacer, based on buoyancy, is widely used to operate pneumatic or electrical pilot devices. The displacer itself moves very little. You can measure light to very heavy liquids with a displacer level gauge. A displacer gauge can operate at high temperatures and pressures and can be made of materials that are not affected by corrosive fluids.

You can use a float or displacer to activate a switch to control the level of liquid. When you work with high temperatures or pressures, or corrosive liquids, you can use a displacer level detector in which the switch mechanism is protected from the process fluid.

Answers to Self-Check Quiz

1-1. a. A fixed reference point. Ref: 1.03

1-2. b. Float. Ref: 1.08

1-3. c. Safety glasses. Ref: 1.11

1-4. c. Sight glass. Ref: 1.12

1-5. c. Weight of liquid displaced. Ref: 1.25

1-6. a. 2 to 7°. Ref: 1.29

1-7. d. Torque tube. Ref: 1.38

1-8. b. High-pressure tanks. Ref: 1.47

1-9. d. Turbulent liquids. Ref: 1.48

1-10. a. Magnetic reed switch. Ref: 1.51

Contributions from the following sources are appreciated:

Figure 1-11 Robertshaw Controls Company
Figure 1-12 Robertshaw Controls Company
Figure 1-13 Robertshaw Controls Company